METHODS, SYSTEMS AND COMPUTER PROGRAM PRODUCTS FOR CARRIER DROP DETECTION USING A VARIABLE THRESHOLD

Field of the Invention

The present invention relates generally to the field of modems, and, more particularly, to modem carrier drop detection.

Background of the Invention

The demand for remote access to information sources and data retrieval, as evidenced by the success of services such as the World Wide Web, is a driving force for high-speed network access technologies. Today's telephone network offers standard voice services over a 4 kHz bandwidth. Traditional analog modem standards generally assume that both ends of a modem communication session have an analog connection to the public switched telephone network (PSTN). Because data signals are typically converted from digital to analog when transmitted towards the PSTN and then from analog to digital when received from the PSTN, data rates may be limited to 33.6 kbps as defined in the V.34 transmission recommendation developed by the International Telecommunications Union (ITU).

The need for an analog modem can be eliminated, however, by using the basic rate interface (BRI) of the Integrated Services Digital Network (ISDN). A BRI offers end-to-end digital connectivity at an aggregate data rate of 160 kbps, which is comprised of two 64 kbps B channels, a 16 kbps D channel, and a separate maintenance channel. ISDN offers comfortable data rates for Internet access, telecommuting, remote education services, and some forms of video conferencing. ISDN deployment, however, has been very slow due to the substantial investment required of network providers for new equipment. Because ISDN is not very pervasive in the PSTN, the network providers have typically tarriffed ISDN services at relatively high rates, which may be ultimately passed on to the ISDN subscribers. In addition to the high service costs, subscribers must generally purchase or lease network

termination equipment to access the ISDN.

While most subscribers do not enjoy end-to-end digital connectivity through the PSTN, the PSTN is nevertheless mostly digital. Typically, the only analog portion of the PSTN is the phone line or local loop that connects a subscriber or client modem (*e.g.*, an individual subscriber in a home, office, or hotel) to the telephone company's central office (CO). In recent years, local telephone companies have been replacing portions of their original analog networks with digital switching equipment. Nevertheless, the connection between the home and the CO has been the slowest to change to digital as discussed in the foregoing with respect to ISDN BRI service. A recent data transmission recommendation issued by the ITU, known as V.90, takes advantage of the digital conversions that have been made in the PSTN. By viewing the PSTN as a digital network, V.90 technology is able to accelerate data downstream from the Internet or other information source to a subscriber's computer at data rates of up to 56 kbps, even when the subscriber is connected to the PSTN via an analog local loop.

To understand how the V.90 recommendation achieves this higher data rate, it may be helpful to briefly review the operation of V.34 analog modems. V.34 modems are optimized for the situation where both ends of a communication session are connected to the PSTN by analog lines. Even though most of the PSTN is digital, V.34 modems treat the network as if it were entirely analog. Moreover, the V.34 recommendation assumes that both ends of the communication session suffer impairment due to quantization noise introduced by analog-to-digital converters. That is, the analog signals transmitted from the V.34 modems are sampled at 8000 times per second by a codec upon reaching the PSTN with each sample being represented or quantized by an eight-bit pulse code modulation (PCM) codeword. The codec uses 256, non-uniformly spaced, PCM quantization levels defined according to either the μ-law or A-law companding standard (*ie.,* the ITU G.711 Recommendation).

Because the analog waveforms are continuous and the binary PCM codewords are discrete, the digits that are sent across the PSTN can only approximate the original analog waveform. The difference between the original analog waveform and the reconstructed quantized waveform is called quantization noise, which limits the modem data rate.

While quantization noise may limit a V.34 communication session to 33.6 kbps, it nevertheless affects only analog-to-digital conversions. The V.90 standard relies on the lack

of analog-to-digital conversions outside of the conversion made at the subscriber's modem to enable transmission at 56 kbps.

The general environment for which the V.90 standard was developed is depicted in **FIG. 1**. An Internet Service Provider (ISP) **22** is connected to a subscriber's computer **24** via a V.90 digital server modem **26**, through the PSTN **28** via digital trunks (*e.g.*, T1, E1, or ISDN Primary Rate Interface (PRI) connections), through a central office switch **32**, and finally through an analog loop to the client's modem **34**. The central office switch **32** is drawn outside of the PSTN **28** to better illustrate the connection of the subscriber's computer **24** and modem **34** into the PSTN **28**. It should be understood that the central office **32** is, in fact, a part of the PSTN **28**. The operation of a communication session between the subscriber **24** and an ISP **22** is best described with reference to the more detailed block diagram of **FIG. 2**.

Transmission from the server modem **26** to the client modem **34** will be described first. The information to be transmitted is first encoded using only the 256 PCM codewords used by the digital switching and transmission equipment in the PSTN **28**. These PCM codewords are transmitted towards the PSTN by the PCM transmitter 6 where they are received by a network codec. The PCM data is then transmitted through the PSTN **28** until reaching the central office **32** to which the client modem **34** is connected. Before transmitting the PCM data to the client modem **34**, the data is converted from its current form as either μ-law or A-law companded PCM codewords to pulse amplitude modulated (PAM) voltages by the codec expander (digital-to-analog (D/A) converter) **38**.

These PAM voltage levels are processed by a central office hybrid **42** where the unidirectional signal received from the codec expander **38** is transmitted towards the client modem **34** as part of a bidirectional signal. A second hybrid **44** at the subscriber's analog telephone connection converts the bidirectional signal back into a pair of unidirectional signals. Finally, the analog signal from the hybrid **44** is converted into digital PAM samples by an analog-to-digital (A/D) converter **46**, which are received and decoded by the PAM receiver **48**. Note that for transmission to succeed effectively at 56 kbps, there must be only a single digital-to-analog conversion and subsequent analog-to-digital conversion between the server modem **26** and the client modem **34**. Recall that analog-to-digital conversions in the PSTN **28** can introduce quantization noise, which may limit the data rate as discussed

hereinbefore. The A/D converter **46** at the client modem **34**, however, may have a higher resolution than the A/D converters used in the analog portion of the PSTN 28 (*e.g.*, 16 bits versus 8 bits), which results in less quantization noise. Moreover, the PAM receiver **48** needs to be in synchronization with the 8 kHz network clock to properly decode the digital PAM samples.

Transmission from the client modem **34** to the server modem **26** follows the V.34 data transmission standard. That is, the client modem **34** includes a V.34 transmitter **52** and a D/A converter **54** that encode and modulate the digital data to be sent using techniques such as quadrature amplitude modulation (QAM). The hybrid **44** converts the unidirectional signal from the digital-to-analog converter **54** into a bidirectional signal that is transmitted to the central office **32**. Once the signal is received at the central office **32**, the central office hybrid **42** converts the bidirectional signal into a unidirectional signal that is provided to the central office codec. This unidirectional, analog signal is converted into either μ-law or A-law companded PCM codewords by the codec compressor (A/D converter) **56**, which are then transmitted through the PSTN **28** until reaching the server modem **26**. The server modem **26** includes a conventional V.34 receiver **58** for demodulating and decoding the data sent by the V.34 transmitter **52** in the client modem **34**. Thus, data is transferred from the client modem **34** to the server modem **26** at data rates of up to 33.6 kbps as provided for in the V.34 standard.

The V.90 standard only offers increased data rates (*e.g.*, data rates up to 56 kbps) in the downstream direction from a server to a subscriber or client. Upstream communication still takes place at conventional data rates as provided for in the V.34 standard. Nevertheless, this asymmetry is particularly well suited for Internet access. For example, when accessing the Internet, high bandwidth is most useful when downloading large text, video, and audio files to a subscriber's computer. Using V.90, these data transfers can be made at up to 56 kbps. On the other hand, traffic flow from the subscriber to an ISP consists of mainly keystroke and mouse commands, which are readily handled by the conventional rates provided by the V.34 standard.

The V.90 standard, therefore, provides a framework for transmitting data at rates up to 56 kbps provided the network is capable of supporting the higher rates. The most notable requirement is that there can be at most one digital-to-analog conversion and no analog-to-

digital conversion in the downstream path within the network. Nevertheless, other digital impairments, such as robbed bit signaling (RBS) and digital mapping through PADs which results in attenuated signals, can also inhibit transmission at V.90 rates. Communication channels exhibiting non-linear frequency response characteristics are yet another impediment to transmission at the V.90 rates. Moreover, these other factors may limit conventional V.90 performance to less than the 56 kbps theoretical data rate.

Articles such as Humblet *et al.*, "The Information Driveway," IEEE Communications Magazine, December 1996, pp. 64-68, Kalet *et al.*, "The Capacity of PCM Voiceband Channels," IEEE International Conference on Communications '93, May 23-26, 1993, Geneva, Switzerland, pp. 507-511, Fischer et al., "Signal Mapping for PCM Modems," V-pcm Rapporteur Meeting, Sunriver, Oregon, USA, September 4-12, 1997, and Proakis, "Digital Signaling Over a Channel with Intersymbol Interference," Digital Communications, McGraw-Hill Book Company, 1983, pp. 373, 381, provide general background information on digital communication systems.

Various modem protocols include startup phases which, in practice, are implemented using, carrier drop detection. For example, the V.90 standard, along with other standards, such as the V.34 standard, begin startup operations with phase 1 procedures classified as network interaction. The phase 1 network interaction segment of startup operations is followed by the phase 2 operations classified as channel probing and ranging. Additional procedures are defined for phase 2 and phase 3 under the V.90 standard. At various points in the startup procedures for V.90 and other modem protocols, carrier drop detection may be utilized to transition the client and server modems to transition to subsequent operations. The transitions may include reconfiguration of receivers and/or other related operations.

It is known to provide modems with carrier detectors as described, for example in United States Patent Nos. 5,563,908 and 5,625,643. These disclosures relate to use of an energy detector as a carrier detector and further using a fixed threshold to recognize carrier drop. These references further discuss an implementation of such a detector which is directed towards improving performance when the signal is subject to effects such as time dispersion. More particularly, a tone signal is appended to the data transmission, the tone signal being used to detect the absence of a carrier indicating the end of the data transmission.

However, many of the proposed protocols preclude the use of such an appended tone

and alternative approaches to improving reliability of carrier drop detection for such systems are needed. One proposed approach to carrier drop detection is described in United States Patent No. 5,815,534 entitled "Detector of Carrier Loss in a Fax Modem" (the '534 patent). The '534 patent discusses a carrier loss detector which utilizes a variable threshold rather than a fixed threshold to detect the end of a page of a fax transmission. A particular frequency pattern associated with a phase of a transmission pursuant to the V.27 standard is used to initiate updating of the threshold input to the carrier loss detection circuit. For example, in one embodiment of the '534 patent, the update is initiated based on a comparison of the magnitude of an unfiltered carrier signal to the magnitude of a filtered version with the filtering selected to cause a deviation between the signals during the phase with a particular associated frequency pattern. As with the approach of adding a tone, such an identifiable frequency pattern is not always available at the points where carrier drop detection is required under various modem communication standards such as V.90. Accordingly, improved carrier drop detection would be beneficial for use under such conditions.

Summary of the Invention

It is an object of the present invention to provide methods, systems and computer program products which may more reliably detect carrier drop in a modem.

It is a further object of the present invention to provide such methods, systems and computer program products which may be tolerant of variations in line conditions and carrier signal levels.

These and other objects, advantages, and features of the present invention are provided by methods, systems and computer program products which utilize a variable threshold for carrier drop detection. The carrier drop detection threshold is updated based on a recognized data sequence (signal data) contained within the signal received by the modem. The received signal is demodulated to obtain the signal data and an updated threshold is latched when a desired data sequence is recognized in the demodulated data. Accordingly, the threshold may be updated and set as an offset from or a percentage of the carrier signal level at the time of receipt of the desired data sequence. For example, in a V.90 modem using a V.8 phase 1 sequence, receipt of the CM signal (for the answer modem) or the JM signal (for the call modem) may be used to latch an updated level for the carrier drop

detection threshold, which may then be used for detecting carrier drop during the silence transmission at the end of phase 1 to allow reliable preparation of the modem for receipt of the INFO0 signal at the start of phase 2.

In one embodiment of the present invention, a method for modem carrier drop detection is provided including demodulating a received signal to provide signal data and updating a carrier drop detection threshold based on the received signal responsive to a selected data pattern in the signal data. A carrier drop is then detected based on the carrier drop detection threshold. In one embodiment, the modem uses a V.8 standard during startup and the carrier drop detection threshold is updated responsive to a selected data pattern in the signal data corresponding to at least one of a CM signal and a JM signal.

In a further embodiment of the present invention, carrier drop detection operations include setting a flag to indicate receipt of at least one of a valid CM signal and a valid JM signal and latching an output of a signal strength detector responsive to setting of the flag, the signal strength detector being coupled to the received signal and the output of the signal strength detector corresponding to a signal strength level of the received signal. The carrier drop detection threshold is then set to a value a predetermined amount below the latched output of the signal strength detector responsive to setting of the flag. The signal strength detector may be a magnitude detector or an energy detector. The carrier drop detection threshold is preferably set to a level about 4 dB below the latched output of the energy detector responsive to setting of the flag. The flag may be set by setting a predetermined memory location as the flag or, alternatively, by setting a latch output line to an active state.

In another embodiment of the present invention, a carrier drop is detected corresponding to a silence transmission terminating a V.8 standard phase 1. The modem is then conditioned to receive a phase 2 INFO0 signal. The modem may be conditioned by starting a differential phase shift keyed (DPSK) receiver that receives the INFO0 signal.

In a further aspect of the present invention, a carrier drop detection system is provided including a demodulator that demodulates a received signal to provide signal data and a threshold circuit coupled to the demodulator that latches a carrier drop detection threshold at a level based on the received signal responsive to a selected data pattern in the signal data. A carrier drop detection circuit coupled to the threshold circuit detects a carrier drop based on the carrier drop detection threshold. The demodulator may be a frequency shift keyed (FSK)

demodulator. In one embodiment, the carrier drop detection circuit includes an energy detector having an output corresponding to an energy level of the received signal, the output of the energy detector being latched responsive to the selected data pattern in the signal data and a comparator coupled to the output of the energy detector and to the carrier drop detection threshold. The selected data pattern in the data signal may be at least one of a CM signal and a JM signal. In one embodiment, the threshold circuit further includes a combiner coupled to the output of the energy detector and an offset that outputs the carrier drop detection threshold as the latched output of the energy detector reduced by the offset. In an alternative embodiment, the threshold circuit further includes a multiplier coupled to the output of the energy detector and a coefficient that outputs the carrier drop detection threshold as the latched output of the energy detector multiplied by the coefficient.

In a further embodiment of the present invention, a carrier drop detection system for a V.8 standard modem startup sequence is provided including a receiver circuit that receives a signal and a detector circuit coupled to the receiver circuit that detects at least one of a CM signal and a JM signal from the received signal. A signal strength detection circuit coupled to the receiver outputs a received signal strength for the received signal. A threshold circuit coupled to the receiver circuit latches a carrier drop detection threshold based on a current value of the received signal strength responsive to detection of at least one of the CM and the JM signal by the receiver circuit. A comparator circuit coupled to the threshold circuit and the signal strength detection circuit compares the received signal strength to the carrier drop detection threshold to detect a carrier drop corresponding to an end of the startup sequence.

As will further be appreciated by those of skill in the art, while described above primarily with reference to method aspects, the present invention may be embodied as methods, apparatus/systems and/or computer program products.

Brief Description of the Drawings

Other features of the present invention will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the accompanying drawings, in which:

FIG. 1 is block diagram illustrating a typical V.90 connection between a subscriber and an ISP in accordance with the prior art;

FIG. 2 is a detailed block diagram of the internal architecture and connections between the client modem, the central office, and the server modem of **FIG. 1**;

FIG. 3 is a block diagram of a carrier drop detection system for a modem in accordance with an embodiment of the present invention;

FIG. 4 is a signal sequencing diagram illustrating the exchange of messages and tones between a server modem and a client modem during phase 1 and part of phase 2 operations pursuant to the V.90 standard; and

FIG. 5 is a flowchart illustrating operations of a carrier drop detection system shown in **FIG. 3**.

Detailed Description of the Preferred Embodiments

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference numbers signify like elements throughout the description of the figures.

As will be appreciated by those skilled in the art, the present invention can be embodied as a method, a system, or a computer program product. Accordingly, the present invention can take the form of an entirely hardware embodiment, an entirely software (including firmware, resident software, micro-code, *etc.*) embodiment, or an embodiment containing both software and hardware aspects. Furthermore, the present invention can take the form of a computer program product on a computer-usable or computer-readable storage medium having computer-usable program code means embodied in the medium for use by or in connection with an instruction execution system. In the context of this document, a computer-usable or computer-readable medium can be any means that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

The computer-usable or computer-readable medium can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor

system, apparatus, device, or propagation medium. More specific examples (a nonexhaustive list) of the computer-readable medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, and a portable compact disc read-only memory (CDROM). Note that the computer-usable or computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via, for instance, optical scanning of the paper or other medium, then compiled, interpreted or otherwise processed in a suitable manner if necessary, and then stored in a computer memory.

Computer program code for carrying out operations of the present invention is typically written in a high level programming language such as C or C++. Nevertheless, some modules or routines may be written in assembly or machine language to optimize speed, memory usage, or layout of the software or firmware in memory. Assembly language is typically used to implement time-critical code segments.

The present invention will now be further described with reference to the block diagram illustration of an embodiment of a carrier drop detection system of **FIG. 3**. As shown in the embodiment of **FIG. 3**, the carrier drop detection system **290** includes the receiver **300** which receives a signal input, such as over a Public Switched Telephone Network (PSTN), and outputs a received signal **302.** The received signal **302** is provided to the demodulator **305** and to the signal strength detector circuit **315** which is contained within the carrier drop detection circuit **310**. The carrier drop detection circuit **310** further includes a comparator **320** which outputs the carrier drop signal **345**. The signal strength output **325** of the signal strength detector **315** is provided to the comparator **320** and also to the threshold circuit **335**.

The demodulator **305** demodulates the received signal **302** to provide signal data **330**. The threshold circuit **335** receives the signal data **330** from the demodulator **305** and latches a carrier drop detection threshold **337** at a level based on the signal strength **325** of the received signal **302** responsive to detection of a selected data pattern in the signal data **330**. The carrier drop detection circuit **310** detects carrier drop with reference to the carrier drop detection threshold **337** and the signal strength **325**.

Also shown in threshold circuit **335** is an offset **340** which may be an offset value used by the threshold circuit **335** to reduce the value of a signal strength **325** latched by the threshold circuit **335** to arrive at the carrier drop detection threshold **337**. Alternatively, the offset **340** may be a coefficient and the carrier drop detection threshold **337** may be the latched value of the signal strength **325** multiplied by the coefficient. Accordingly, depending upon the embodiment as described above, the threshold circuit **335** may further include either a combiner (not shown) that outputs the carrier drop detection threshold **337** as the latched value of the signal strength **325** from the signal strength detector circuit **315** reduced by the offset **340** or a multiplier (not shown) that outputs the carrier drop detection threshold **337** as the latched value of the signal strength **325** multiplied by the coefficient.

The present invention will now be further described within the context of a particular embodiment directed to detection of the phase 1 to phase 2 transition for a V.90 (or V.34) client or analog modem. In particular, detection of the INFO0 signal at the start of phase 2 for a V.90 modem may be difficult in that the INFO0 signal in phase 2 is typically sent only once following the completion of phase 1 of the startup protocol. If for some reason, such as signal noise, the INFO0 signal is not received within the time window allowed for the INFO0 signal reception, a V.90 modem typically must time out and perform an error recovery procedure where the transmitter continuously sends the INFO0 signal to the remote modem and the receiver similarly continuously tries to detect the INFO0 signal coming from the remote modem. Accordingly, performance may be improved by reliable detection of the INFO0 signal initially without the use of an INFO0 recovery procedure. One approach to this problem is to provide a robust receiver for the INFO0 signal which, typically, is received by a differential phase shift keyed (DPSK) receiver. Alternatively, or an addition to the use of such a robust receiver, the phase 1 to phase 2 transition may be accurately and reliably detected to improve performance. Carrier drop detection methods, systems and computer program products according to the present invention are particularly beneficial for applications such as the detection of the phase 1 to phase 2 transition as will now be further described with reference to **FIG. 4**.

Tone and message transmissions with their respective relative timing for the server modem and the client modem are illustrated in **FIG. 4**. In the illustration of **FIG. 4,** the client/analog modem acts as the call modem which transmits CI (or CT or CNG) and

conditions its receiver to detect the answer signal ANSam (or ANS) as per the V.8 protocol recommendation. After the signal ANSam is detected, the call modem transmits silence for the period T_e. The call modem then conditions its receiver to detect JM and transmits the signal CM with the appropriate bit set to indicate that V.90 operation is desired. When a minimum of two identical JM sequences have been received, the call modem completes the current CM octet and sends CJ. After sending CJ, the call modem transmits silence for 75 milliseconds plus or minus 5 milliseconds before proceeding with the phase 2 signal procedures. As shown in **FIG. 4,** the phase 2 signals from the call modem begin with transmission of the INFO0 signal.

The answer (or server/digital) modem, as illustrated in **FIG. 4,** transmits the ANSam signal and conditions its receiver to receive CM. After two identical CM sequences are received with the appropriate bit set to indicate V.90 operation, the answer modem sends JM and conditions its receiver to detect CJ. After receiving the three specified octets of CJ, the answer modem transmits silence for 75 milliseconds plus or minus 5 milliseconds and proceeds with phase 2 of the startup procedures.

During the 75 millisecond silence period ending phase 1, both the call modem and answer modem start their INFO0 DPSK receivers to detect the INFO0 signal. For example, with reference to the call modem side, as soon as the detection of the JM signal is completed, the V.8 supporting circuitry of the call modem starts to monitor for carrier drop of the phase 1 signal (specified pursuant to the V.21 protocol recommendation). On detection of the carrier drop, the V.8 circuitry of the call modem signals to the rest of the modem system that the phase 1 receiving task is completed and the 75 millisecond silence period has started. The DPSK INFO0 receiver then begins operation. In known V.90 modems, an absolute carrier drop threshold is compared with an energy detector output and, once the energy detector output drops below the set carrier drop threshold, carrier drop is said to be detected.

While an absolute carrier drop may work well under normal line conditions, trouble may result under various line conditions which can cause a wrong start time for the INFO0 DPSK receiver which in turn results in a failure to detect the original INFO0 signal and the need to enter INFO0 error recovery procedures. For example, under noisy line conditions, it may be difficult to reliably and repeatedly detect carrier drop. This is particularly difficult in contexts such as the V.90 sequence described above as the transmissions during which carrier

drop detection is applied are "silence" conditions and it is generally hard to establish a fixed threshold for detection of carrier drop during a silence period. This problem is further magnified by the relatively short duration of the 75 millisecond silence period between phase 1 and phase 2. As a result of this short period, it is possible with prior approaches that the carrier detector output may not even have an opportunity to drop, i.e., to reach the threshold for drop detection, within the 75 millisecond time frame, which results in a failure to detect carrier drop. Also, as the phase 2 INFO0 signal is inband to the V.21 reception, the echo of the INFO0 signal itself could also disturb the carrier detector's energy output. Accordingly, the present invention provides for establishment of a relative threshold for use in detecting the phase 1 to phase 2 transition. As will be described further herein, the present invention utilizes recognition of receipt of the CM and/or JM signal respectively, depending upon whether it is the call modem or the answer modem, to initiate updating of the carrier threshold.

Referring again to **FIG. 3**, the illustrated embodiment of the present invention will be further described with reference to the application and detection of carrier drop between phase 1 and phase 2 for a V.90 modem. For this embodiment, the demodulator **305** may be a frequency shift keyed (FSK) demodulator as phase 1, pursuant to the V.8 standard recommendation, includes transmissions of CM (or JM) packets containing one and zero patterns modulated using V.21 standard FSK modulation. While such signals typically cannot be detected through the use of tone detection, they may be recognized through demodulation and comparison to the expected associated patterns pursuant to the V.8 standard. In addition, the signal strength detector **315** is preferably an energy detector which is configured to detect an energy level of the received signal **302** . While it is possible to utilize a signal strength detector **315** which is a magnitude type detector, it is preferable that an energy detector be utilized in accordance with the present invention. Furthermore, as described previously with reference to **FIG. 4,** the threshold circuit **335** latches the output of the signal strength detector **315** on recognition of at least one of the CM signal or the JM signal as the selected data pattern in the data signal **330**. Accordingly, the threshold circuit **335** further comprises a detector circuit which is coupled to the receiver **300** through the demodulator **305** so as to detect at least one of the CM signal or the JM signal.

It is further to be understood that while the receiver **300** and the modulator **305** are illustrated as separate blocks in **FIG. 3** they may be combined. Similarly, other blocks or combinations of blocks in **FIG. 3** may be implemented in whole or in part as code executing on a processor, in custom chips, in discrete devices or as a combination of the above.

Operations according to the present invention will now be further described with reference to the embodiment illustrated in the flow chart of **FIG. 5**. As shown in **FIG. 5,** operations begin at block **500** with receipt of the signal by the modem including the carrier drop detection system **290**. The received signal is demodulated to provide signal data (block **505**). As will be described further with reference to blocks **510** through **525,** a carrier drop detection threshold is updated based on the received signal responsive to a selected data pattern in the signal data.

As the illustrated embodiment of **FIG. 5** relates to detection of the phase 1 to phase 2 transition for a modem using a V.8 standard during startup, the signal data from block **505** is evaluated to detect a selected data pattern in the signal data corresponding to at least one of a CM signal or a JM signal depending upon whether the modem is acting as the call modem or the answer modem (block **510**). If a CM or JM signal is not received, operations return to block **500**. Once a CM or a JM signal is detected (block **510**), a flag is set to indicate to the rest of the modem system that a valid CM or JM has been received (block **515**). The phase 1 V.21 standard receiver (not shown) within the circuitry of the threshold circuit **335** latches the output of the signal strength (energy) detector **315** (block **520**). Accordingly, the current output of the energy detector **315** is latched responsive to setting of the flag indicating receipt of a valid CM or JM signal.

The carrier drop detection threshold **337** is then set to a value a predetermined amount below the last output of the signal strength detector **315** responsive to the setting of the flag (block **525**). In one embodiment of the present invention, the relative threshold value for the carrier drop detection threshold **337** is set to a level four dB (decibels) below that of the latched output of the signal strength detector **315**. Subsequently, on receipt of the silence transmission between phase 1 and phase 2, a carrier drop is detected when the output of the signal strength (energy) detector **315** drops below the updated threshold as detected by the comparator **320** (block **530**). Finally, following detection of a carrier drop (block **530**), the modem is conditioned to receive the phase 2 INFO0 signal (block **535**). More particularly,

the conditioning operations at block **535** may include starting a Differential Phase Shift Keyed (DPSK) receiver to receive the INFO0 signal.

In a preferred embodiment, the flag set operations at block **515** comprise setting a predetermined memory location as the flag which memory location is accessible to the various program code modules executing on the modem. Alternatively, operations at block **515** can utilize a hardware connection where setting of the flag comprises setting a latched output line to an active state to initiate latching operations as described above.

The systems, methods and computer program products according to the present invention provide for the use of an updated or relative carrier drop threshold. As a result, modem transition timing, such as the phase 1 to phase 2 transition timing for V.90 modem, may be more reliably detected across a variety of line conditions. The present invention may, thereby, provide for improved reliability of operations following carrier drop detection, such as the detection of the phase 2 INFO0 signal in a V.90 (or a V.34) modem.

The present invention has been described above with reference to the block diagram illustration of **FIG 3**. and the flowchart illustration of **FIG 4**. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These program instructions may be provided to a processor to produce a machine, such that the instructions which execute on the processor create means for implementing the functions specified in the flowchart or block diagram block or blocks. The computer program instructions may be executed by a processor to cause a series of operational steps to be performed by the processor to produce a computer implemented process such that the instructions which execute on the processor provide steps for implementing the functions specified in the flowchart or block diagram block or blocks.

Accordingly, blocks of the block diagrams and/or flowchart illustrations support combinations of means for performing the specified functions, combinations of steps for performing the specified functions and program instruction means for performing the specified functions. It will also be understood that each block of the block diagrams and/or flowchart illustrations, and combinations of blocks in the block diagrams and/or flowchart illustrations, can be implemented by special purpose hardware-based systems which perform

the specified functions or steps, or combinations of special purpose hardware and computer instructions.

It should also be noted that, in some alternative implementations, the functions noted in the blocks may occur out of the order noted in the figures. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved.

While the present invention has been illustrated and described in detail in the drawings and foregoing description, it is understood that the embodiments shown are merely exemplary. Moreover, it is to be understood that many variations and modifications can be made to the embodiments described herein above without substantially departing from the principles of the present invention. All such variations and modifications are intended to be included herein within the scope of the present invention, as set forth in the following claims.